A Method of Increasing Per Capita Real Income by Twenty Times

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This paper explains a method of economic growth under the free trade system. As the trade is carried out along the comparative advantage, the comparative advantage plays an important role for economic growth. When three patterns of comparative advantage is entirely achieved, per capita output increases nearly twenty times in comparison with the initial stage of economic growth.

Keywords : Productivity　Comparative Advantage　Free Trade　Economic Growth
Physical Capital　Human Capital　Technology

Introduction

How can we become wealthily? The answer is a rise of productivity. We have to raise productivity. Then how can we raise productivity? This is the most important subject on economics.

There are some economic factors that affect productivity. One of those is the trade, and the trade has an effect on a rise of productivity. A rise of productivity leads to the economic growth, but the relation of trade and economic growth is not clear. Though we have many studies that the economic growth affects the trade, we do not almost have a study that the trade affects the economic growth. Many countries that achieved the economic growth had an open economy system. Therefore we can think some relation of trade and economic growth.

There are two reasons that the trade contributes to the economic growth. One of those is efficiency that is based on the comparative advantage. The trade is carried out along the comparative advantage. As the comparative advantage raises productivity, the trade is efficient. The other is a scale economy caused by expanding of a market to the world. As a scale economy lowers an average cost, productivity rises. If the increasing returns occur, the output increases more. Whether the trade brings the increasing returns is not exactly. But the trade will bring a scale economy.

The trade has two effects on the increase of production factor and the rise of productivity. These are main factors of economic growth, and this is why many

developing countries have an open economy system.

We think how the developing country achieves an economic development. We think a method of raising per capita real income by the economic growth model. We make the economic growth model including the trade. The trade is carried out along the comparative advantage, which causes the specialization in order of labor-intensive goods, capital-intensive goods and knowledge-intensive goods.

1 The feature of developing country

As the income of developing country is low level, the saving is limited. And as the saving is limited, the investment is also few. Consequently the capital is insufficient. Therefore the developing country is not suitable for the specialization in capital-intensive goods and knowledge-intensive goods. The developing country does not also have the technology that can produce capital-intensive goods and knowledge-intensive goods.

Though the developing country does not have the capital and technology, the developing country has many labors. Though the quality of labor may be not high, the wage is low level. Therefore the developing country is suitable for the specialization in labor-intensive goods. How does the developing country get the capital and technology that need to produce labor-intensive goods? The developing country can get the capital and technology from other country.

The capital, labor and technology are the factor of economic growth, and the developing country is short of these factors. The developing country can achieve the economic growth by combining home labor and the capital and technology from other country. As the wage is low level, the developing country could easily get the comparative advantage for labor-intensive goods. The developing country increases the output and exports them to a foreign country. The export-led economy is one way of economic development. In order to achieve a higher economic growth, the developing country needs to get the comparative advantage for capital-intensive goods and knowledge-intensive goods. The comparative advantage for capital-intensive goods and knowledge-intensive goods is more difficult than the comparative advantage for labor-intensive goods.

The comparative advantage occurs in order of labor-intensive goods, capital-intensive goods and knowledge-intensive goods. Because the specialization in capital-intensive goods needs the high level of income and the specialization in knowledge-intensive goods needs the high level of education. The economic development of developing

country begins from the specialization in labor-intensive goods, but it is not sure whether the developing country can reach at the specialization in capital-intensive goods and knowledge-intensive goods.

2 The model

We think the economic growth model along the comparative advantage principle. The comparative advantage consists of the specialization in labor-intensive goods, capital-intensive goods and knowledge-intensive goods.

We think the production function that the output is decided by the physical capital and the human capital. And we think that the human capital is caused by the education. The human capital is divided to the one for education and the one for production. The human capital for production is entered in the production function. Denoted the output as Y and the physical capital as K and the human capital as H, the production function is

$$Y(t) = K(t)^{\alpha} (1 - b) H(t)^{\beta} \quad (1)$$

$$0 < \alpha < 1 \qquad 0 < \beta < 1$$

As the b denotes a ratio of human capital for education, (1-b) denote a ratio of human capital for production. This formula denotes that the output is a function of the physical capital and the human capital for production.

The α denotes a contribution of the physical capital to the output and β denotes a contribution of the human capital to the output. The value of α and β affects the output. The α and β is respectively more than 0 and less than 1.

The dynamics of physical capital is

$$\dot{K}(t) = s\, Y(t) \quad (2)$$

The s is a ratio of physical capital to the output.

The dynamics of human capital is

$$\dot{H}(t) = b\, H(t)^{\theta} \; [A\, L(t)^{(1-\theta)}] \quad (3)$$

The A is a technology level. The L denotes labor and AL is called effective labor. The θ is a contribution of education to the human capital and the $(1-\theta)$ is a contribution

of labor to the human capital. This type of technological progress is a labor-saving one. This has a character that a ratio of capital to the output is constant.
The dynamics of A and L is

$$\dot{A}(t) = g\,A(t) \tag{4}$$

$$\dot{L}(t) = n\,L(t) \tag{5}$$

The A and L respectively changes by a constant ratio g and n.
Divided Y and K and H by AL respectively we think the output, the physical capital and the human capital of effective labor unit.

$$y = \frac{Y}{AL}$$

$$k = \frac{K}{AL}$$

$$h = \frac{H}{AL}$$

Therefore the formula (1) changes

$$y(t) = k(t)^{\alpha}\,(1-b)\,h(t)^{\beta} \tag{6}$$

The dynamics of k at a steady state is

$$\dot{k}(t) = s\,k(t)^{\alpha}\,(1-b)\,h(t)^{\beta} - (n+g)\,k(t) = 0 \tag{7}$$

At a balanced growth path, k is

$$k = \left[\frac{s(1-b)}{(n+g)}\right]^{\frac{1}{1-\alpha}} h^{\frac{\beta}{1-\alpha}} \tag{8}$$

The dynamics of h at a steady state is

$$\dot{h}(t) = b\,h(t)^{\theta} - (n+g)\,h(t) = 0 \tag{9}$$

At a balanced growth path, h is

$$h = \left[\frac{b}{(n + g)} \right]^{\frac{1}{1-\theta}} \tag{10}$$

Therefore the (6) formula is

$$y^* = k^{*\alpha} (1 - b) h^{*\beta} \tag{11}$$

When we take a logarithm of (8), (10) and (11) we get the next formula.

$$\ln k^* = \frac{1}{1-\alpha} \cdot (\ln s + \ln(1 - b) - \ln(n + g)) + \frac{1}{1-\theta} \cdot \frac{\beta}{1-\alpha} \cdot (\ln b - \ln(n + g)) \tag{12}$$

$$\ln h^* = \frac{1}{1-\theta} \cdot (\ln b - \ln(n + g)) \tag{13}$$

$$\ln y^* = \alpha \ln k^* + \ln(1 - b) + \beta \ln h^* \tag{14}$$

When we substitute (12) and (13) formula for (14) formula, we get the next formula.

$$\ln y^* = \frac{\alpha}{1-\alpha} \cdot (\ln s - \ln(n + g)) + \frac{1}{1-\alpha} \cdot (\ln(1 - b) - (\ln(n + g)) + \frac{\beta}{1-\theta} \cdot \left[\frac{\alpha}{1-\alpha} \cdot (\ln b - \ln(n + g)) + (\ln b - \ln(n + g)) \right] \tag{15}$$

3 The economic development under free trade system

As the trade is carried out along the comparative advantage, the developing country firstly specializes in labor-intensive goods. The developing country that specializes in labor-intensive goods is a labor abundant country, and the rate of labor increase is high. If the rate of technological progress exceeds the rate of labor increase, effective labor unit n + g fall. After all the output, the physical capital and the human capital of effective labor unit increase, and per capita output and per capita physical capital and per capita human capital also increase.

After the specialization in labor-intensive goods, the country specializes in capital-intensive goods. The increase of income induces the increase of saving and causes the increase of capital. The country that specializes in capital-intensive goods is a capital

abundant country, and the rate of technological progress is high. Therefore effective labor unit n + g fall.

Next to the specialization in capital-intensive goods, the country specializes in knowledge-intensive goods. As the specialization in knowledge-intensive goods needs much knowledge and experience, a ratio of human capital for education is higher than the case of specialization in labor-intensive goods and in capital-intensive goods. As a rate of technological progress is also high, effective labor unit n + g fall.

How long does the economic development along the comparative advantage take? How can the developing country catch up with the developed countries? The important factors of economic growth in the long term are the inputs of capital and labor. In (6) formula they are given by k and h. In the developing countries and the developed countries, the quantity of k and h are entirely different. Therefore the developing countries firstly need to get k and h. As k and h are the physical capital and the human capital of effective labor unit, the rate of technological progress is also the important factors of economic growth.

The quantity of input affects the economic development. By the combination of quantity of input and comparative advantage, we can explain the economic difference of developing countries and developed countries.

(1) The case of specialization in labor-intensive goods

In this case the value of n is high. When the economy is under a free trade system, the rate of technological progress is also high. Therefore effective labor unit n + g fall. If the value of n + g falls 10 percent by the specialization in labor-intensive goods, we get next formula. The subscript 1 denotes before the change and the subscript 2 denotes after the change.

$$\begin{aligned} \ln y_2^* - \ln y_1^* = & \frac{\alpha}{1-\alpha} \cdot -(\ln(n_2+g) - \ln(n_1+g)) + \\ & \frac{1}{1-\alpha} \cdot -(\ln(n_2+g) - \ln(n_1+g)) + \\ & \frac{\beta}{1-\theta} \cdot \left[\left(\frac{\alpha}{1-\alpha}\right) \cdot -(\ln(n_2+g) - \ln(n_1+g)) - \right. \\ & \left. (\ln(n_2+g) - \ln(n_1+g)) \right] \\ = & -0.67(\ln 0.9) - 1.67(\ln 0.9) - 0.56(\ln 0.9) - \\ & 0.83(\ln 0.9) \simeq 0.39 \end{aligned}$$

We suppose that α is 0.4, β is 0.5 and θ is 0.4. As $e^{0.39}$ is 1.48, per capita output rises 48 percent in comparison with no trade case.

(2) The case of specialization in capital-intensive goods

In this case the rate of saving is high due to the increase of income by the economic growth. And the rate of technological progress is high in comparison with the case of specialization in labor-intensive goods. By the specialization in capital-intensive goods, if the value of s rises 30 percent and n + g fall 20 percent, we get next formula.

$$\begin{aligned}
\ln y_2^* - \ln y_1^* = & \frac{\alpha}{1-\alpha} \cdot \Big[(\ln s_2 - \ln s_1) - \\
& (\ln(n_2+g) - \ln(n_1+g)) \Big] + \\
& \frac{1}{1-\alpha} \cdot -(\ln(n_2+g) - \ln(n_1+g)) + \\
& \frac{\beta}{1-\theta} \cdot \Big[\left(\frac{\alpha}{1-\alpha}\right) \cdot -(\ln(n_2+g) - \ln(n_1+g)) - \\
& (\ln(n_2+g) - \ln(n_1+g)) \Big] \\
= & \ 0.67(\ln 1.3) - 0.67(\ln 0.8) - 1.67(\ln 0.8) - \\
& 0.67(\ln 0.8) - (\ln 0.8) \simeq 1.07
\end{aligned}$$

We suppose that α is 0.4, β is 0.5 and θ is 0.5. The value of θ is higher than the case of specialization in labor-intensive goods. As $e^{1.07}$ is 2.91, per capita output increases nearly three times in comparison with no trade case.

(3) The case of specialization in knowledge-intensive goods

As the production of knowledge-intensive goods increases in this case, we need a human resource that has a high technology and wisdom. By the specialization in knowledge -intensive goods, if a ratio of human capital for education rises 10 percent and n + g fall 20 percent, we get next formula. A ratio of human capital for production falls 10 percent.

$$\begin{aligned}
\ln y_2^* - \ln y_1^* = & \frac{\alpha}{1-\alpha} \cdot -(\ln(n_2+g) - \ln(n_1+g)) + \\
& \frac{1}{1-\alpha} \cdot \Big[(\ln(1-b_2) - \ln(1-b_1)) - \\
& (\ln(n_2+g) - \ln(n_1+g)) \Big] + \\
& \frac{\beta}{1-\theta} \cdot \Big[\frac{\alpha}{1-\alpha} \cdot \Big[(\ln b_2 - \ln b_1) - \\
& (\ln(n_2+g) - \ln(n_1+g)) \Big] + \\
& (\ln b_2 - \ln b_1) - (\ln(n_2+g) - \ln(n_1+g)) \Big] \\
= & -0.67(\ln 0.8) + 1.67(\ln 0.9) - 1.67(\ln 0.8) + \\
& 0.84(\ln 1.1) - 0.84(\ln 0.8) + 1.25(\ln 1.1) - \\
& 1.25(\ln 0.8) \simeq 1.01
\end{aligned}$$

We suppose that α is 0.4, β is 0.5 and θ is 0.6. The value of θ is higher than the case of specialization in capital-intensive goods. As $e^{1.01}$ is 2.75, per capita output increases nearly 2.7 times in comparison with no trade case. A ratio of human capital for education induces the increase of human capital. Therefore the contribution of human capital to the output may become big. This possibility is expressed by a rise of β in the (6) formula.

(4) The dynamics of comparative advantage

The economic development in open economy is achieved by the process of specialization in labor-intensive goods, capital-intensive goods and knowledge-intensive goods. When three patterns of comparative advantage is achieved, how much does per capita output increase? If a ratio of physical capital to the output rises 30 percent and a ratio of human capital for education rises 10 percent and n + g fall 50 percent, we get next formula.

$$
\begin{aligned}
\ln y_2^* - \ln y_1^* = {} & \frac{\alpha}{1-\alpha} \cdot \Big[(\ln s_2 - \ln s_1) - \\
& (\ln(n_2 + g) - \ln(n_1 + g)) \Big] + \\
& \frac{1}{1-\alpha} \cdot \Big[(\ln(1 - b_2) - \ln(1 - b_1)) - \\
& (\ln(n_2 + g) - \ln(n_1 + g)) \Big] + \\
& \frac{\beta}{1-\theta} \cdot \Big[\frac{\alpha}{1-\alpha} \cdot \Big[(\ln b_2 - \ln b_1) - \\
& (\ln(n_2 + g) - \ln(n_1 + g)) \Big] + \\
& (\ln b_2 - \ln b_1) - (\ln(n_2 + g) - \ln(n_1 + g)) \Big] \\
= {} & 0.67(\ln 1.3) - 0.67(\ln 0.5) - 1.67(\ln 0.5) + \\
& 0.67(\ln 1.1) - 0.67(\ln 0.5) + (\ln 1.1) - \\
& (\ln 0.5) + 1.67(\ln 0.9) \simeq 2.95
\end{aligned}
$$

We suppose that α is 0.4, β is 0.5 and θ is 0.5. As $e^{2.95}$ is 19.03, per capita output increases nearly twenty times.

This difference of per capita output is due to the size of s, b and g. If n + g falls 2 percent every year, the 50 percent fall of n + g needs 25 years. That is this difference of per capita output needs 25 years. Is this estimate adequate?

Some countries needed nearly twenty or thirty years from the initial stage of economic growth to the standard growth. The twenty times of per capita output

also need the rise of 30 percent for s and 10 percent for b. In order to achieve the twenty times of per capita output, all conditions must be satisfied. The period that all conditions must be satisfied is not distinct.

And the country that is expected to satisfy these conditions is the developing country. Because per capita output is quite low in the initial stage of economic growth. As a result what level per capita output is to be depends on the initial stage of economic growth.

Conclusion

Many countries that achieved the economic growth had an open economic system. The export-led economy is one way of economic growth for the developing country. As the trade is carried out along the comparative advantage, the comparative advantage plays an important role for economic growth.

The economic development in an open economy is achieved by the process of specialization in labor-intensive goods, capital-intensive goods and knowledge-intensive goods. The developing country will start from the production of labor-intensive goods. That is why they could not produce capital-intensive goods and knowledge-intensive goods. This means that the developing country specializes in labor-intensive goods. After the economy grew and the income increased to some extent, the developing country specializes in capital-intensive goods and knowledge-intensive goods.

When n + g falls 10 percent by the specialization in labor-intensive goods, per capita output rises nearly 48 percent in comparison with no trade case. When a ratio of physical capital to the output rises 30 percent by the specialization in capital-intensive goods per capita output increases nearly three times in comparison with no trade case. And when a ratio of human capital for education rises 10 percent by the specialization in knowledge-intensive goods per capita output increases nearly 2.7 times in comparison with no trade case.

When three patterns of comparative advantage is entirely achieved, per capita output increases nearly twenty times in comparison with the initial stage of economic growth. Generally this period needs nearly twenty years or thirty years. This is a method for the economic development.

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